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COAL STRENGTH PARAMETERS DERIVED FOR THE DONKIN-MORIEN HARBOUR SEAM, SYDNEY COALFIELD, N.S.

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Cape Breton Coal Research Laboratory

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by

T.R.C. Aston*, L.S. O'Leary** and D.A. Young**

ABSTRACT

As part of ongoing geotechnical research activities at the Cape Breton Coal Research Laboratory, samples were collected from the Donkin-Morien Harbour seam bulk coal driveage. A programme of irregular lump point load testing was undertaken and uniaxial and tensile strength parameters derived. Strength values are given both parallel and perpendicular to the bedding plane and an anisotropy index calculated. A preliminary comparison between the Donkin-Morien and other Sydney Coalfield data reveals that the Donkin-Morien Harbour seam properties are very similar to those obtained from No. 26 Colliery.

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ÉLABORATION DES PARAMÈTRES DE RÉSISTANCE DU CHARBON DU GÎTE DONKIN-MORIEN HARBOUR DE LA HOUILLÈRE DE SYDNEY, N.-É.

par

T.R.C. Aston*, L.S. O'Leary** et D.A. Young**

RÉSUMÉ

Dans le cadre des activités de recherche géotechniques du Laboratoire de recherche sur le charbon du Cap-Breton, on a recueilli des échantillons de la galerie de charbon en vrac du gîte Donkin-Morien Harbour. Un programme d'essai de charge concentrée de charbon en roche irrégulier a été réalisé et des paramètres de résistance uniaxiale et de résistance à la traction ont été fixés. Le rapport présente les coefficients de résistance parallèle et perpendiculaire au plan de stratification et les résultats du calcul de l'indice d'anisotropie. Une comparaison préliminaire des données recueillies à Donkin-Morien Harbour et de celles provenant d'autres filons de la houillère de Sydney indiquent que les propriétés du gîte Donkin-Morien Harbour sont très semblables aux propriétés de la mine N° 26.

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INTRODUCTION

In February 1985, an inseam driveage was undertaken in the Harbour Seam at chainage 3478 m within the Donkin-Morien No. 2 access tunnel to extract a bulk coal sample. During development of this inseam driveage, CBCRL staff installed a variety of geotechnical instrumentation to monitor strata movement. To provide additional information and extend the rock property data base currently being established for the Sydney Coalfield, coal samples from the Harbour Seam were collected and subsequently tested using the technique of irregular lump point load testing. A previous programme utilizing the technique has already been undertaken in the Sydney Coalfield in order to obtain a 'first order approximation' of coal strength properties (1).

This report presents the results obtained from the Harbour Seam bulk coal driveage in the Donkin-Morien No. 2 access tunnel along with a preliminary comparison of the results against those obtained from the Sydney Coalfield.

POINT LOAD TESTING

The point load testing apparatus is shown in Figure 1 and its operation fully described in the Pit Slope Manual (2).

Essentially, the test involves loading a sample of known shape and size between two points, Figure 2. Extensive work (2,3,4) has reported the factors affecting the test and proposed the method as a valid means of determining a rock strength index.

The point load index, I, is derived using equation (1).

$$I = P/D^2 \qquad \text{Eq 1}$$

where, P = Point Load (MPa)

D = Diameter of the Specimen (mm)

In the case of irregular specimen testing, the samples should be roughly spheroidal in shape with a preferred diameter of 50 mm. However,

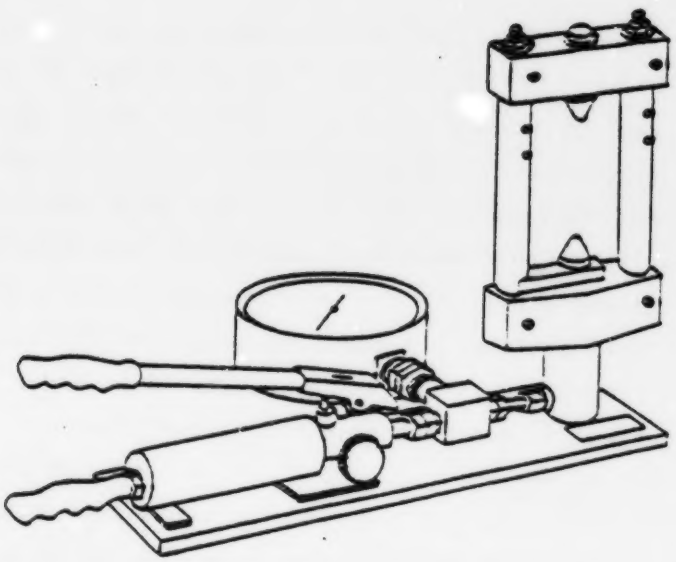
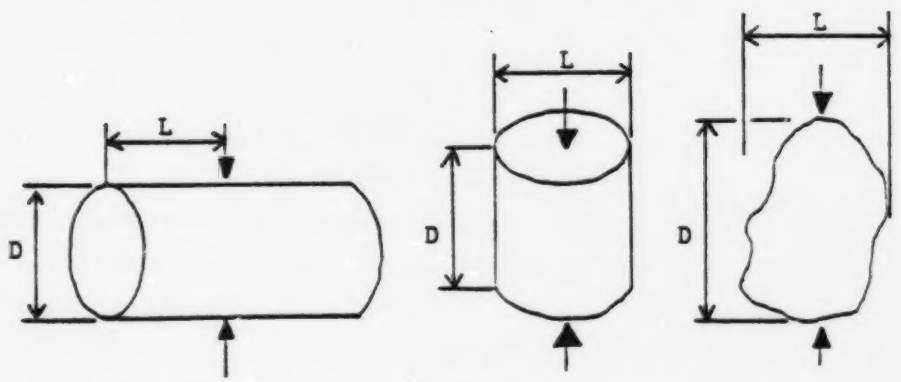


Figure 1 - Point-Load Test Apparatus (Manufactured by ELE Ltd., U.K.) (Ref. 4)



$L > 0.7\ D$

Diametral Test

$\frac{D}{L} = 1.1 \pm 0.05$

Axial Test

$\frac{D}{L} = 1.0$ to 1.4

Irregular Lump Test

Figure 2 - Types of Point Load Strength Tests (Ref. 4)

maximum and minimum diameters of 100 mm and 25 mm are acceptable (2). The acceptable ratio of the longest to shortest diameter of the specimen falls between 1.0 and 1.4, Figure 2.

TESTING PROGRAMME

Samples were collected at intermittent intervals along the driveage and consisted of lumps which had spalled from the coal seam. Careful selection was undertaken to eliminate those containing stone or obvious poor quality coal. A minimum sample size of 100 mm was collected and subsequently prepared in the laboratory (reduction to between 25 mm and 50 mm and roughly spheroidal in shape). Once collected, the samples were transported to surface, sealed in plastic sacks, stored overnight and tested on site the following morning.

One hundred and seven samples were tested with fifty being tested parallel and fifty-seven perpendicular to the coal bedding. The results were subsequently tabulated and Is values calculated for each of the samples, along with a mean batch diameter and index strength. The data in tabulated form is given in Appendix A.

TEST RESULTS

The diameter of a specimen can exert a significant influence on the derived value, even though the length/diameter criteria are maintained (2,3,4). It is therefore, important to standardize the reporting of index data according to specimen diameter.

The Pit Slope Manual (2) gives a size correction chart for calculating the Is_{54} value to a reference diameter of 50 mm. However, an extensive study by Hassani et al. (4) has shown that mathematical equations can be derived which represent the correction curves and therefore avoid the problems associated with distortion and inadequate reproduction of the original chart.

Index values have, therefore, been corrected to 54 mm (standard NX size core) using equation (2), (Ref. 4).

$$\text{Log}_{10}Is_{54} = 0.229 + \text{Log}_{10}I - 1.008e^{-0.0274\,(D)} \qquad \text{Eq 2}$$

where, I = Index Strength (MPa)

D = Specimen Diameter (mm)

Hassani et al. (4) have also reported relationships between the point load index strength, uniaxial strength and tensile strength as follows:

Uniaxial Compressive Strength Eq 3

$$\sigma_c = 29.24\ Is_{54}$$

Tensile Strength Eq 4

$$Ts = 2.78\ Is_{54}$$

Encouraging results have also been reported for calculating triaxial strength data from point load testing using a variety of established models (4), although no attempt has been made here.

Mean Is_{54}, tensile and compressive strength values are given in Table 1, while the results are tabulated in Appendix A.

DISCUSSION

In Table 1, the Donkin-Morien Harbour Seam coal has a mean compressive strength of 11 MPa parallel and 15 MPa perpendicular to the bedding. It is therefore stronger perpendicular rather than parallel to the bedding.

Variations in the Is_{54} coal strength values seen in Appendix A are probably due to localised changes in the coal lithology even though samples were carefully selected to eliminate those containing stone or obvious poor quality coal.

Table 1 - Mean coal specimen values for the Donkin-Morien No. 2 Tunnel, Harbour Seam

	Parallel to Bedding	Perpendicular to Bedding
Specimen Size (mm)	37	36
Load (MPa)	0.68	0.89
Is Value (MPa)	0.58	0.79
Is_{54} Value (MPa)	0.38	0.52
Tensile Strength (MPa)	1.05	1.44
Compressive Strength (MPa)	11.05	15.11

Table 2 shows coal properties derived for the Donkin-Morien Harbour Seam along with those obtained from elsewhere within the Sydney Coalfield (1). In general, the Donkin-Morien coal appears most similar to that from No. 26 Colliery, Table 3:

Table 3 - Comparative Is_{54}, tensile and compressive strength values for the Harbour Seam at Donkin-Morien and No. 26 Colliery

	Donkin-Morien	No. 26 Colliery
Compressive Strength (MPa)	11.0	9.3
Tensile Strength (MPa)	1.0	0.9
Is_{54} Anisotropy Index	1.37	1.44

The Donkin-Morien Harbour Seam coal is markedly dissimilar to that seen at Prince mine or NOVACO in that it is stronger perpendicular rather than parallel to the direction of bedding. Although similar in strength to the Harbour Seam at No. 26 Colliery, Table 3, it is much weaker than similar samples collected from the Lingan mine: Uniaxial Compressive Strength 11 MPa (parallel) compared with 17 MPa, Table 2.

Table 2 - Point load index, uniaxial compressive strength, tensile strength and Hardgrove grindability index values of coal, Sydney Coalfield, Nova Scotia

Date	Mine Site (seam)	Direction of loading relative to bedding	Index strength Is_{54} (MPa)	Calculated Uniaxial Compresive Strength (MPa)	Calculated Tensile Strength (MPa)	Anisotropy Index Is_{54}	Hardgrove grindability index
21/12/83	No. 26	Parallel	0.32	9.3	0.89		
	(Harbour)	Perpendicular	0.46	13.5	1.28	1.44	65-70
21/12/83	Lingan	Parallel	0.58	16.9	1.60		
	(Harbour)	Perpendicular	1.23	35.8	3.41	2.13	56-62
05/01/84	Lingan	Parallel	0.58	16.9	1.61		
	(Harbour)	Perpendicular	1.22	35.7	3.39	2.10	56-62
05/01/84	Prince	Parallel	0.75	22.0	2.10		
	(Hub)	Perpendicular	0.41	12.0	1.14	0.54	59-63
05/01/84	NOVACO	Parallel	0.26	7.6	0.72		
	(Main)	Perpendicular	0.18	5.2	0.50	0.69	58
05/03/85	Donkin-Morien	Parallel	0.38	11.0	1.05		
	(Harbour)	Perpendicular	0.52	15.1	1.44	1.37	-

No Hardgrove grindability values for the Donkin-Morien coal are currently available, although it is again expected that coal strength cannot be correlated with the grindability index (1,5).

Finally, it should be noted that the data obtained during this programme is presented in Appendix A. The reason for this inclusion is that, in future, refined or even new techniques for the determination of rock strength parameters from point load test data may become available. It is therefore considered important that the original data used to derive the Donkin-Morien Harbour Seam coal strengths be made available for re-evaluation by future researchers.

CONCLUSION

The point load index test provides a simple, effective means of deriving rock strength parameters under field and/or laboratory conditions. However, inherent problems do exist with the technique, especially when deriving compressive and tensile strength values from the original index values. The values given in Tables 1, 2 and 3 should, therefore, be treated with caution and used primarily as a 'good first order approximation' of coal strength in the Donkin-Morien Harbour Seam and Sydney Coalfield mine sites.

ACKNOWLEDGEMENTS

The authors wish to gratefully acknowledge the support and assistance provided by Cape Breton Development Corporation personnel at the Donkin-Morien Development Project site.

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APPENDIX A

CAPE BRETON COAL RESEARCH LABORATORY

LOCATION DONKIN MINE-CROSS CUT #1

DATE MARCH 5/85 # OF TESTS 50 FILE NAME S2

SAMPLE DESCRIPTION COAL IRREGULAR LUMP.TESTED PARALLEL TO PLANE.

POINT #	SPECIMEN DIAMETER mm	LOAD kN	Is	Is 54	TENSILE STRENGTH	UNIAXIAL COMPRESSIVE STRENGTH
1	52	.900	.33	.32	.90	9.43
2	40	.800	.50	.39	1.08	11.40
3	33	2.400	2.20	1.46	4.06	42.66
4	27	.430	.62	.35	.96	10.10
5	22	.075	.15	.07	.20	2.16
6	63	1.075	.27	.30	.84	8.88
7	56	.625	.20	.20	.57	5.99
8	43	.375	.20	.17	.47	4.92
9	40	.625	.39	.30	.85	8.91
10	30	.625	.69	.42	1.18	12.40
11	25	.375	.60	.32	.88	9.23
12	18	.450	1.39	.57	1.59	16.68
13	73	.475	.09	.11	.31	3.23
14	48	.500	.22	.20	.55	5.77
15	40	.625	.39	.30	.85	8.91
16	33	.975	.90	.59	1.65	17.33
17	29	.625	.74	.44	1.23	12.90
18	26	.175	.26	.14	.39	4.11
19	24	.750	1.30	.66	1.84	19.38
20	20	.175	.44	.19	.54	5.67
21	66	1.100	.25	.29	.81	8.35
22	45	.900	.44	.38	1.06	11.20
23	39	1.325	.87	.67	1.85	19.45
24	31	.300	.31	.20	.54	5.73
25	23	.625	1.18	.58	1.62	17.01

CAPE BRETON COAL RESEARCH LABORATORY

LOCATION BONKIN MINE-CROSS CUT #1

DATE MARCH 5/85 # OF TESTS 50 FILE NAME S2

SAMPLE DESCRIPTION COAL IRREGULAR LUMP.TESTED PARALLEL TO PLANE.

POINT #	SPECIMEN DIAMETER mm	LOAD kN	Is	Is 54	TENSILE STRENGTH	UNIAXIAL COMPRESSIVE STRENGTH
26	19	.075	.21	.09	.25	2.59
27	50	.600	.24	.23	.63	6.59
28	38	1.125	.78	.58	1.62	17.01
29	33	1.075	.99	.65	1.82	19.11
30	28	.975	1.24	.72	1.99	20.97
31	24	.175	.30	.15	.43	4.52
32	14	.375	1.91	.67	1.85	19.49
33	44	1.100	.37	.48	1.34	14.05
34	38	.975	.68	.50	1.40	14.74
35	34	.800	.69	.47	1.31	13.74
36	28	.900	1.15	.66	1.84	19.36
37	24	.275	.48	.24	.68	7.11
38	53	.800	.28	.28	.78	8.20
39	44	1.325	.68	.58	1.61	16.92
40	30	.200	.22	.14	.38	3.97
41	24	.225	.39	.20	.55	5.81
42	53	.275	.10	.10	.27	2.82
43	45	.300	.15	.13	.35	3.73
44	43	.800	.43	.36	1.00	10.49
45	32	.425	.42	.27	.74	7.83
46	26	.175	.26	.14	.39	4.11
47	53	.700	.25	.25	.68	7.17
48	40	.825	.32	.40	1.12	11.76
49	32	.825	.81	.52	1.44	15.19
50	55	1.375	.45	.46	1.28	13.47

MEAN VALUES

MEAN SPECIMEN DIAMETER = 37.
MEAN LOAD KN = .681
MEAN Is = .58
MEAN Is 54 = .38
MEAN TS = 1.05
MEAN UCS = 11.05

CAPE BRETON COAL RESEARCH LABORATORY

LOCATION DONKIN MINE-CROSS CUT #1

DATE MARCH 5/85 # OF TESTS 57 FILE NAME S3

SAMPLE DESCRIPTION COAL-IRREGULAR LUMP.TESTED PERPENDICULAR TO PLANE

POINT #	SPECIMEN DIAMETER mm	LOAD kN	Is	Is 54	TENSILE STRENGTH	UNIAXIAL COMPRESSIVE STRENGTH
1	49	.725	.30	.28	.78	8.16
2	37	1.525	1.11	.81	2.26	23.77
3	19	.800	2.22	.95	2.63	27.65
4	37	.625	.46	.33	.93	9.74
5	34	.375	.32	.22	.61	6.44
6	36	2.750	2.12	1.51	4.21	44.24
7	30	.700	.78	.48	1.32	13.89
8	35	4.500	3.67	2.56	7.11	74.77
9	29	.475	.56	.34	.93	9.81
10	38	.275	.19	.14	.40	4.16
11	30	.175	.19	.12	.33	3.47
12	50	2.300	.92	.86	2.40	25.27
13	60	.625	.17	.19	.52	5.49
14	58	2.025	.60	.64	1.77	18.57
15	43	1.075	.58	.48	1.34	14.10
16	28	1.175	1.50	.86	2.40	25.27
17	47	1.025	.46	.41	1.15	12.12
18	38	.425	.29	.22	.61	6.43
19	19	.375	1.04	.44	1.23	12.96
20	30	1.175	1.31	.80	2.22	23.32
21	20	.475	1.19	.53	1.46	15.38
22	53	.175	.06	.06	.17	1.79
23	30	2.400	2.67	1.63	4.53	47.63
24	27	.075	.10	.06	.16	1.68
25	20	.175	.44	.19	.54	5.67

CAPE BRETON COAL RESEARCH LABORATORY

LOCATION DONKIN MINE-CROSS CUT #1

DATE MARCH 5/85 # OF TESTS 57 FILE NAME S3

SAMPLE DESCRIPTION COAL-IRREGULAR LUMP.TESTED PERPENDICULAR TO PLANE

POINT #	SPECIMEN DIAMETER mm	LOAD kN	Is	Is 54	TENSILE STRENGTH	UNIAXIAL COMPRESSIVE STRENGTH
26	60	.275	.08	.08	.23	2.42
27	52	.625	.23	.22	.62	6.55
28	47	.175	.08	.07	.20	2.07
29	37	.600	.44	.32	.89	9.35
30	34	2.675	2.31	1.57	4.37	45.95
31	24	.300	.52	.27	.74	7.75
32	56	.300	.10	.10	.27	2.87
33	44	.725	.37	.32	.88	9.26
34	35	.250	.20	.14	.39	4.15
35	27	1.725	2.37	1.32	3.68	38.73
36	20	.850	2.13	.94	2.62	27.52
37	45	.475	.23	.20	.56	5.91
38	40	1.400	.88	.68	1.90	19.96
39	32	1.525	1.49	.96	2.67	28.09
40	25	.475	.76	.40	1.11	11.69
41	44	.600	.31	.26	.73	7.66
42	31	.700	.73	.46	1.27	13.37
43	33	2.125	1.95	1.29	3.59	37.77
44	44	.225	.12	.10	.27	2.87
45	37	.300	.22	.16	.44	4.68
46	32	.300	.29	.19	.53	5.53
47	28	.125	.16	.09	.26	2.69
48	39	1.675	1.10	.84	2.34	24.58
49	31	.275	.29	.18	.50	5.25
50	27	.275	.38	.21	.59	6.17

CAPE BRETON COAL RESEARCH LABORATORY

LOCATION DONKIN MINE-CROSS CUT #1

DATE MARCH 5/85 # OF TESTS 57 FILE NAME S3

SAMPLE DESCRIPTION COAL-IRREGULAR LUMP.TESTED PERPENDICULAR TO PLANE

POINT #	SPECIMEN DIAMETER mm	LOAD kN	Is	Is 54	TENSILE STRENGTH	UNIAXIAL COMPRESSIVE STRENGTH
51	44	.375	.19	.16	.46	4.79
52	37	.775	.57	.41	1.15	12.08
53	32	1.075	1.05	.68	1.88	19.80
54	34	.900	.78	.53	1.47	15.46
55	46	1.475	.70	.61	1.70	17.88
56	33	.225	.21	.14	.38	4.00
57	30	.650	.72	.44	1.23	12.90

MEAN VALUES

MEAN SPECIMEN DIAMETER = 36.
MEAN LOAD KN = .893
MEAN Is = .79
MEAN Is 54 = .52
MEAN TS = 1.44
MEAN UCS = 15.11